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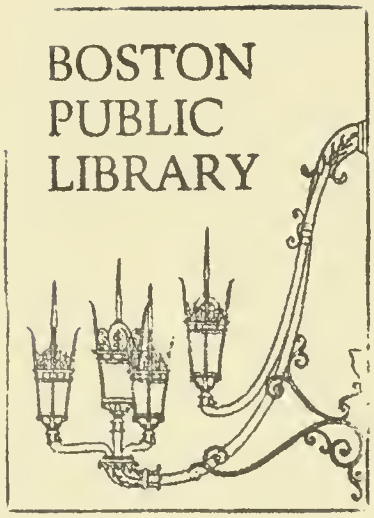

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PRELIMINARY AIR QUALITY IMPACT ASSESSMENT OF THE PROPOSED PARK PLAZA PROJECT IN BOSTON, MASSACHUSETTS

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I. SUMMARY OF AIR QUALITY IMPACTS

A preliminary air quality impact assessment was undertaken to characterize the probable impacts of induced roadway traffic associated with the proposed Park Plaza Project in Boston, Massachusetts. The objective of this preliminary assessment was to rank and evaluate the relative impacts of the various project design alternatives for Park Plaza. For the purposes of this analysis, the maximum 1-hour and 8-hour carbon monoxide (CO) levels which could arise as a consequence of both adverse meteorological conditions and peak roadway traffic (the "worst-worst" case) were evaluated at seven sensitive receptor sites along the perimeter of the proposed project area. No background concentrations were included in the model predictions. These receptor sites correspond to locations where maximum public exposure to high levels of CO emissions is expected to occur.

Motor vehicles are also major contributors to nitrogen oxide and reactive hydrocarbon emissions in the community. These contaminants participate in a series of complex photochemical reactions for which the current atmospheric diffusion modeling technology does not permit preparation of reliable estimates of projected concentration levels. However, CO is relatively inert and can be predicted by current modeling techniques. In addition, CO is the pollutant emitted in the largest quantities from automotive sources.

Detailed modeling simulations were conducted of projected 1985 motor vehicle emissions and their dispersion in urban street canyons. Based upon this modeling analysis, motor vehicle traffic associated with the Park Plaza Project will increase ambient CO levels in the project area in 1985, relative to the 1985 no-build condition. The relative percentage increases projected for the 3, 4, 5, and 6 million alternatives* are, respectively, 4, 10, 20, and 19 percent. However, CO levels for the project build alternatives in 1985 are predicted to be lower than current (1975) levels. The

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* Reference is being made here to the millions of square feet of building area associated with each redevelopment alternative.

principal cause of this reduction is the expected reduction in average motor vehicle emission rates due to implementation of the revised Boston Transportation Control Plan and the progressive shifting of the vehicle population with time towards newer vehicles with additional emissions control equipment. The projected net percentage decreases in ambient CO levels in the project area in 1985, relative to current (1975) concentrations, for the 3, 4, 5, and 6 million build alternatives are, respectively, 64, 62, 58, and 58 percent. Thus, although none of the four build alternatives is projected to cause an increase in community CO concentrations above current levels, of the four, the 3 million build alternative will allow for the greatest improvement in air quality.

II. INTRODUCTION

The impact of an urban redevelopment project, such as Park Plaza, on community air quality levels comes principally from project-induced motor vehicle traffic. Thus, our analysis focused on the increase in motor vehicle emissions associated with projected changes in traffic patterns affected by Park Plaza.

A. EMISSIONS FROM MOTOR VEHICLES

The principal contaminants emitted by motor vehicles are carbon monoxide, unburned and partially burned hydrocarbons, oxides of nitrogen, partial oxidation products, and particulate matter. The particulate matter in exhaust emissions consists of both inorganic and organic compounds of high molecular weight. A brief review of the known effects of these air pollutants on health, materials, and other receptors is presented in the Appendix.

In 1972, gasoline-powered motor vehicles contributed 54 percent of all hydrocarbons, 74 percent of all carbon monoxide, and 28 percent of all nitrogen oxides emitted into the air in the United States. The motor vehicle presently still constitutes the greatest contributor by volume to air pollution in the urban environment. In some cities, this contribution is as much as 90 percent of the total. This situation can be expected to continue to exist until Federal and State control plans currently being developed are implemented.

The present schedule of stringent Federal regulations on motor vehicle emissions control is designed to reduce emissions in new 1978 automobiles by 90 percent from corresponding 1970 model motor vehicle emissions. However, the full effect of these regulations will not be felt until the middle 1980s, when virtually every vehicle on the road will be controlled. In Boston, the effect of these controls on air quality will be further enhanced by traffic control regulations recently revised by the Environmental Protection Agency (EPA). These regulations are described in Section II.D.

B. AMBIENT AIR QUALITY STANDARDS

The historical sequence in the development of a plan to control the emission of these pollutants and to enhance the quality of the ambient air has included the preparation of Air Quality Criteria, followed by the promulgation of Ambient Air Quality Standards. The Air Quality Criteria represent an assembly of current scientific knowledge on the relationship between various concentrations of contaminants in the air and their adverse effects on human beings and their environment. Based on this information, as well as on data collected at public hearings, national Ambient Air Quality Standards were established. These standards prescribe contaminant exposures which should not be exceeded and form the basis for designing legally enforceable abatement programs.

National primary and secondary Air Quality Standards for both Set I pollutants (sulfur oxides and total suspended particulates) and Set II pollutants (carbon monoxide, nitrogen oxides, hydrocarbons, and photochemical oxidants) were promulgated by the Environmental Protection Agency (EPA) on April 13, 1971. The primary standards are intended to protect the public health, while secondary standards are intended to protect the public welfare from any known or anticipated adverse effects. These national standards are summarized in Table 1. The target date for attainment of the national primary standards is 1975, while the secondary standards are to be achieved within a reasonable time period. The table shows that the primary and secondary standards for Set II pollutants, which are largely transportation source pollutants, prescribe the same levels. Achievement of these standards in the Metropolitan Boston Air Quality Control Region has been extended to mid-1977.

C. TRANSPORTATION CONTROL PLANS

Under the Clean Air Act of 1970, all states were required to submit plans for meeting the national ambient air quality standards set by EPA in 1971. Transportation Control Plans (TCPs) are required for any air quality control region where controls on stationary sources--such as power plants and other industries--combined with Federal new car emission standards are

TABLE 1

FEDERAL AND MASSACHUSETTS AIR QUALITY STANDARDS

Contaminant	Averaging Time	Concentration Primary Std. µg/m³	Concentration Primary Std. ppm	Concentration Sec. Std. µg/m³	Concentration Sec. Std. ppm	Measurement Criteria*
Sulfur Oxides (SO_2)	Year	80	0.03	—	—	Arithmetic Mean
	Day	365	0.14	—	—	Maximum
	3 Hours	—	—	1,300	0.5	Maximum
Total Suspended Particulates (TSP)	Year	75	—	60**	—	Geometric Mean
	Day	260	—	150	—	Maximum
Carbon Monoxide (CO)	8 Hours	10,000	9	10,000	9	Maximum
	1 Hour	40,000	35	40,000	35	Maximum
Photochemical Oxidants (O_3)	1 Hour	160	0.08	160	0.08	Maximum
Hydrocarbons (Non-Methane)	3 Hours	160†	0.24	160	0.24	Maximum between 6 a.m. and 9 a.m.
Nitrogen Oxides (NO_2)	Year	100	0.05	100	0.05	Arithmetic Mean

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* Standards other than those based on annual arithmetic or geometric mean are not to be exceeded more than once per year.

** For use as a guide in assessing implementation plans to achieve the 24-hour TSP standard.

† For use as a guide in devising implementation plans to achieve the oxidant standard.

inadequate to insure attainment or maintenance of the ambient standards.

To meet air quality standards, many major urban areas, including Boston, must control emissions from motor vehicles to a greater extent than would be afforded by the Federal new car emission controls. The effectiveness of a given control strategy must be weighed against alternative measures making up the total control plan with regard to both the reduction in air pollution it offers and the social and economic dislocation the area might suffer in the process.

In general, two broad types of transportation controls have been considered: those which reduce emissions from individual motor vehicles, such as installing control devices on each uncontrolled car, and those which reduce emissions from all vehicles as a class, such as restricting vehicle travel. Most plans submitted to EPA by the states employ a combination of strategies to meet the required air quality standards. The most common strategies include inspection and maintenance programs; the installation of so-called "retrofit" devices to control automobile emissions; and traffic control measures such as traffic flow improvement, mass transit improvement, parking bans, exclusive bus lanes, car pooling, and methods to cut back the total vehicle miles traveled.

D. METROPOLITAN BOSTON TRANSPORTATION CONTROL PLAN

The revised Boston Transportation Control Plan (BTCP) proposed by EPA on June 12, 1975, is composed of a series of land use and transportation control procedures. The principal elements of the Plan are shown in Table 2, along with the projected dates of implementation. The proposed program has two main elements:

1. An inspection and maintenance system, to ensure that the pollution control equipment on each registered automobile remains in suitable working order.
2. A program of parking restrictions and other incentives for reducing single-passenger commuter automobile use.

TABLE 2

SUMMARY OF THE REVISED METROPOLITAN BOSTON TRANSPORTATION CONTROL PLAN*

	Control Strategy	Projected Date of Full Implementation
I.	SEMI-ANNUAL INSPECTION/MAINTENANCE PROGRAM	
	All Light- and Medium-Duty Vehicles (10,000 pounds gross vehicle weight or less)	August 1, 1976
II.	PARKING MANAGEMENT PROGRAM	
	A. Morning On-Street Parking Ban**	March 1, 1977
	B. Commercial Off-Street Parking Freeze***	October 15, 1973
	C. Restrictions on Construction or Modification of Parking Facilities	†
III.	COMMUTER AUTOMOBILE USE REDUCTION	
	A. Mandatory Incentive Measures by Commuter-Attracting Facilities†† to Reduce Single-Passenger Commuting Vehicle Usage by 25%	June 30, 1976
	B. Computer Carpool Matching Program	June 30, 1975
	C. Feasibility Study of Preferential Bus and Carpool Incentives	December 31, 1976
	D. Study of Improved Bicycle Pathways and Facilities	June 30, 1976
IV.	CO "HOT SPOT" CONTROL STRATEGIES	May 31, 1977
V.	ORGANIC SOLVENT USE REGULATIONS	May 31, 1977

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* Includes amendments proposed by EPA on June 12, 1975 [40FR25152, 40CFR52]. All regulations refer to the Metropolitan Boston Intrastate Air Quality Control Region unless otherwise noted.

** Applies only to Boston proper and the City of Cambridge.

*** Applies only to the "freeze area" of Boston, the City of Cambridge, and Logan International Airport.

† Reserved pending promulgation of final parking management regulations.

†† Employers with a facility having 50 or more employees and educational institutions with 250 or more commuting students and employees.

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The element of the control plan aimed at reducing emissions from individual motor vehicles (viz., inspection/maintenance) was included in the analysis for estimation of future motor vehicle emissions. Because the elements of the control plan designed to reduce single-passenger commuter automobile use were not included in the estimates of future traffic volumes supplied to Walden Research, the air quality analysis provides conservative estimates of future air quality impacts.

III. AIR QUALITY ANALYSIS

A. ANALYSIS OBJECTIVES

The objective of this preliminary assessment was to rank and evaluate the relative impacts on community air quality of the various project design alternatives, including the no-build alternative. The impact of an urban redevelopment project, such as Park Plaza, on community air quality levels can come from two principal types of sources: emissions associated with space heating and cooling requirements and emissions from induced motor vehicle traffic. This latter source was the object of the current analysis and for the purposes of this study was used as an indicator of the relative impacts of the various design alternatives.

The assessment of the impact on air quality of motor vehicle traffic associated with a proposed redevelopment project can be based on a comparison of projected carbon monoxide (CO) concentrations within the project area for the project no-build and build alternatives. Although motor vehicles are also major contributors to nitrogen oxide and reactive hydrocarbon emissions in the community, these contaminants participate in a series of complex photochemical reactions for which current atmospheric diffusion modeling technology does not permit preparation of reliable estimates of projected concentration levels. However, CO is relatively inert and can be predicted using current modeling techniques. In addition, CO is the pollutant emitted in the largest quantities from automotive sources.

For the purposes of this analysis, the maximum 1-hour and 8-hour CO levels which could arise as a consequence of both adverse meteorological conditions and peak roadway traffic (the "worst-worst" case) were evaluated for the no-build case and for four build alternatives. The different build alternatives pertain to project designs ranging from minimal to extensive redevelopment of the project site. The various alternatives, referred to by the building area on the project site, are the 2, 3, 4, 5, and 6 million square feet alternatives. The minimum alternative of 2 million square feet equals the total amount of existing

building area on the site, plus that amount on existing empty lots that would be allowed under the zoning code. Thus, the 2 million alternative approximates the total development conceivable if no urban renewal action is taken and represents a no-build alternative.

No background concentrations were included in predicted CO levels, nor was the atmospheric diffusion model used validated or calibrated with local field measurements. Thus, this analysis is *not* intended to be, nor would it be, adequate for the consideration of air quality impacts in connection with an environmental impact report or statement. Its intended purpose is the determination of the *relative* impacts of several project design alternatives on local CO concentrations.

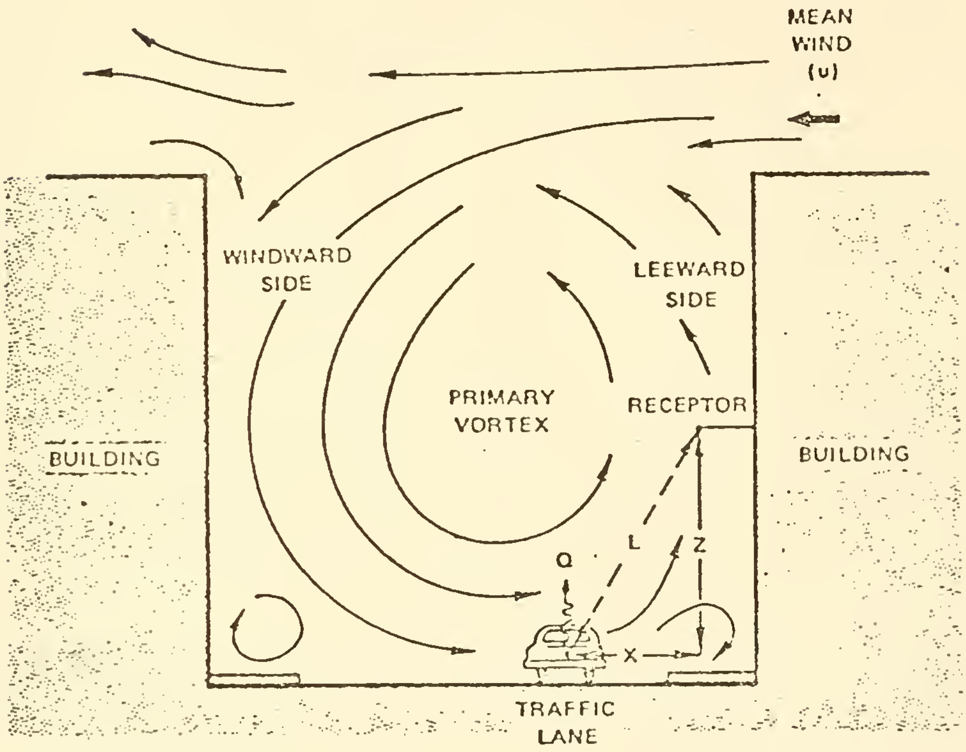
B. DESCRIPTION OF ATMOSPHERIC DIFFUSION MODEL

Successful application of generalized diffusion models to specific emission sources requires definition of the source characteristics. The Park Plaza Project is a proposed redevelopment of a substantial section of downtown Boston, characterized by dense urban development wherein tall buildings (20 to 100 meters high) form street canyons in which the flow of air is channeled. Evidence of a helical air circulation in street canyons, as illustrated in Figure 1, has been observed in a field study [1] of the dispersion of motor vehicle emissions in the urban environment. Receptors on the leeward side of a building are exposed to substantially higher pollutant concentrations than are those on the windward side because of the reverse flow component across the street, near the surface. The APRAC-1A diffusion model [2] has been developed to simulate this street canyon effect and was applied in the current investigation. This model has been used extensively by EPA in the development of urban TCPs.

In the current analysis, the APRAC-1A street canyon submodel was used to simulate the diffusion of CO emissions from motor vehicle traffic on roadways immediately adjacent to the Park Plaza Project site and to predict CO concentrations at a typical breathing height of 2 meters above ground level at selected receptor locations on sidewalks alongside project area roadways. In the model equations, CO concentrations in the

FIGURE 1

ILLUSTRATION OF TYPICAL CROSS-STREET CIRCULATION OF AIR IN AN URBAN STREET CANYON



street canyon are predicted as functions of roadway CO emission rates, street width, average building height, and mean wind speed. For each situation analyzed, the leeward concentration was calculated and used to represent the maximum CO concentrations that would impact upon persons in the urban street canyon.

The canyon model utilized in the current impact assessment was *not* subjected to validation or calibrated with local field measurements. In addition, no ambient monitoring program was undertaken in the current study to characterize background CO levels in the project area. Therefore, the model only gives estimates of predicted 1-hour and 8-hour CO concentrations. Nevertheless, even when uncalibrated, the model can provide reliable estimates of the *relative* impacts of various project alternatives.

C. IMPACT ASSESSMENT DATA

1. Meteorological

In the free-flow atmosphere, the dispersion properties at any particular time can be described in terms of the joint occurrence of three meteorological parameters: mean wind speed, thermal stability, and mixing depth. The latter two do not require specification in the current analysis, since the mechanically induced turbulent flow evident in a street canyon operates independent of the atmospheric thermal stability and mixing depth. The mean wind speed, however, is an important parameter in the canyon model, representing transport and dilution processes. The minimum value of mean wind speed that can be meaningfully used in the APRAC-1A model is 1.0 meters per second. Therefore, this value was used to represent the most adverse meteorological conditions, i.e., poor atmospheric dilution of CO.

2. Traffic

The traffic data utilized in the impact assessment were supplied by The Saratoga Associates for the current (1975) condition and for the build and no-build alternatives in 1985, the expected year of project

completion. The roadways analyzed are those forming the perimeter of the Park Plaza Project area, viz., Boylston, Charles, Tremont, Stuart, and Arlington Streets. The data supplied consisted of peak 1-hour and 8-hour traffic counts from existing roadways and similar data for the future no-build and build alternatives (including additional traffic induced by site redevelopment). The traffic volumes supplied for the future no-build case represent a 15% increase over existing levels to account for probable growth.

Estimates of average vehicle speeds on project area roadways were not available for the current analysis. Instead, estimates of average vehicle speeds in downtown Boston during the periods of peak 1-hour and 8-hour traffic were supplied by the Boston Redevelopment Authority (BRA) and were used in computing CO emissions. These speeds were, respectively, 15 and 20 miles per hour. In the absence of other data, these speeds were also assumed for the future build and no-build alternatives. It should be noted that average vehicle speed is one of the most important determinants of motor vehicle emissions and that the lack of detailed speed data for the project area represents a serious deficiency in this analysis.

D. ESTIMATED MOTOR VEHICLE EMISSION RATES

Estimates of CO emissions from motor vehicles in the project area were calculated, based on the previously discussed average vehicle speeds. The computations were made using a computer program, VEHEMI, which applies the most recent EPA motor vehicle emission factors [3] to the projected traffic volumes on project area roadways. VEHEMI is designed to compute the CO emission rate (grams CO/vehicle mile) for a specified motor vehicle model year mix--in this case, a mix typical of the Boston area. The method is based on a procedure outlined by Kircher and Armostrong [4] and incorporates such considerations as age of vehicles, deterioration of control devices as a function of model year and age, the split between light- and heavy-duty vehicles in the population, and the effect of the BTCP's semi-annual emissions inspection/maintenance program. Recent changes in the Federal automobile emission standards related to amendments to the Clean

Air Act of 1970 and to the suspension by the EPA Administrator of the 1977 standards have been incorporated, along with the most recent estimates of speed adjustment factors [5]. Estimated motor vehicle emission rates, distributed by calendar year and average vehicle speed, are shown in Table 3.

The estimated reduction in CO emission rates from calendar year 1975 to 1985 is principally due to two factors:

- The semi-annual inspection/maintenance program of the BTCP
- Control devices installed on new model automobiles and the progressive shifting of the vehicle population in time toward newer, controlled vehicles.

E. PREDICTED CARBON MONOXIDE CONCENTRATIONS AT SELECTED RECEPTOR LOCATIONS

Detailed modeling simulations were conducted for the project no-build and build alternatives at seven sensitive receptor locations covering the perimeter of the Park Plaza Project. The receptor locations were selected to correspond to points where maximum public exposure to high levels of CO emissions from project area roadways are expected to occur. These receptor locations are:

1. Public Garden (along Boylston Street)
2. Charles Street (near Boylston Street)
3. Boston Common (along Boylston Street)
4. Theater District (along Tremont Street)
5. Stuart Street (near Tremont Street)
6. Howard Johnson's 57 Hotel (along Stuart Street)
7. Statler Hilton Hotel (along Arlington Street)

The "worst-worst" case was assumed in each instance. The APRAC-1A street canyon model [2] was applied to predict 1-hour maximum CO concentrations due to roadway emissions. To obtain 8-hour concentrations, the conservative assumption was made that the meteorological conditions responsible for the 1-hour maxima persisted over an 8-hour interval. This assumption allowed direct scaling of the predicted 1-hour maxima, by appropriate traffic volumes,

TABLE 3

ESTIMATED MOTOR VEHICLE EMISSION RATES FOR CARBON MONOXIDE IN BOSTON

Average Vehicle Speed (mph)	CO Emissions (grams/mile)	
	1975	1985
15	61.0	17.3
20	48.5	14.2

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to predicted 8-hour concentration levels. The traffic scaling factors used in each case were the ratios of 8-hour volume to eight times the peak 1-hour volume. The results are summarized in Tables 4 and 5, respectively, for the predicted 1-hour and 8-hour concentrations. Note that no background concentrations were included in the predicted CO levels.

F. CONCLUSIONS

Tables 4 and 5 show that the maximum predicted 1-hour and 8-hour CO concentrations for the build alternatives are generally higher than those for the no-build alternative in 1985. However, receptor sites along Boylston and Tremont Streets indicate no increase in CO levels associated with the urban redevelopment, since the principal access routes to the project site are not along these streets. To illustrate better the relative impacts of the various project alternatives, the concentrations listed in Table 4 for the four build alternatives were divided by the corresponding future no-build concentrations to obtain relative indices of air quality improvement or deterioration. These ratios are shown in TAble 6 for the peak 1-hour CO levels. Ratios for the 8-hour peak concentrations were identical and, therefore, omitted. The relative impact indices in Table 6 show that, in general, the Park Plaza Project will increase ambient CO levels in the project area in 1985, relative to the no-build condition. The relative percentage increases projected for the 3, 4, 5, and 6 million square feet alternatives are, repsectively, 4, 10, 20, and 19 percent, based on the seven-point averages. It should be emphasized that these predicted concentrations do not include background CO advected into the project area from other sources. The presence of such a background would increase equally all predicted concentrations for a given averaging time and thus would lower the percentage increases associated with site redevelopment.

In Tables 4 and 5, the large predicted decrease in no-build concentration from 1975 to 1985 reflects the expected reduction in average motor vehicle emission rates over the ten-year period (see Table 3), offset slightly by an assumed 15 percent rise in traffic volumes. To illustrate better the net impacts of the various project alternatives, the concentrations listed in Table 4 for the four build alternatives in 1985 were divided

TABLE 4

PREDICTED MAXIMUM 1-HOUR CARBON MONOXIDE CONCENTRATIONS*
AT SELECTED RECEPTOR LOCATIONS (IN PPM)

	Receptor Site	Current (1975) Condition	Future (1985) Alternatives				
			No-Build	3M**	4M	5M	6M
1.	Public Garden	6.7	2.2	2.2	2.2	2.2	2.2
2.	Charles Street	4.2	1.4	1.5	1.6	1.7	1.7
3.	Boston Common	4.6	1.5	1.5	1.5	1.5	1.5
4.	Theater District	4.4	1.5	1.5	1.5	1.5	1.5
5.	Stuart Street	5.8	2.0	2.1	2.3	2.6	2.6
6.	Howard Johnson's 57 Hotel	2.6	1.0	1.2	1.5	1.9	1.9
7.	Statler Hilton Hotel	4.6	1.5	1.6	1.6	1.6	1.6

* Does not include background levels.

** Cases identified by M are the build alternatives. Numbers refer to the millions of square feet of building area associated with each build option.

TABLE 5

PREDICTED MAXIMUM 8-HOUR CARBON MONOXIDE CONCENTRATIONS*
AT SELECTED RECEPTOR LOCATIONS (IN PPM)

	Receptor Site	Current (1975) Condition	Future (1985) Alternatives				
			No-Build	3M**	4M	5M	6M
1.	Public Garden	4.5	1.5	1.5	1.5	1.5	1.5
2.	Charles Street	2.6	0.9	1.0	1.0	1.1	1.1
3.	Boston Common	3.2	1.1	1.1	1.1	1.1	1.1
4.	Theater District	3.0	1.0	1.0	1.0	1.0	1.0
5.	Stuart Street	3.9	1.4	1.5	1.6	1.8	1.8
6.	Howard Johnson's 57 Hotel	1.9	0.8	0.9	1.1	1.4	1.4
7.	Statler Hilton Hotel	2.5	0.9	0.9	0.9	0.9	0.9

* Does not include background levels.

** Cases identified by M are the build alternatives. Numbers refer to the millions of square feet of building area associated with each build option.

TABLE 6

AIR QUALITY IMPACT INDICES FOR THE FOUR BUILD ALTERNATIVES RELATIVE TO THE NO-BUILD ALTERNATIVE IN 1985

	Receptor Site	Relative Air Quality Impact Indices			
		3M	4M	5M	6M
1.	Public Garden	1.00	1.00	1.00	1.00
2.	Charles Street	1.04	1.10	1.18	1.17
3.	Boston Common	1.00	1.00	1.00	1.00
4.	Theater District	1.00	1.00	1.00	1.00
5.	Stuart Street	1.07	1.17	1.31	1.30
6.	Howard Johnson's 57 Hotel	1.17	1.43	1.84	1.82
7.	Statler Hilton Hotel	1.01	1.03	1.07	1.07
	Seven-Point Average:	1.04	1.10	1.20	1.19

by current (1975) concentrations to obtain net indices of air quality improvement or deterioration. These ratios are shown in Table 7 for the peak 1-hour CO levels. The net impact indices show that, in general, the combined effects of the Park Plaza Project and expected reductions in average motor vehicle emission rates will decrease ambient CO levels in the project area in 1985, relative to the current (1975) condition. The net percentage decreases projected for the 3, 4, 5, and 6 million square feet alternatives are, respectively, 64, 62, 58, and 58 percent, based on the seven-point averages. Thus, although none of the four build alternatives is projected to cause an increase in project area concentrations above current levels, of the four, the 3 million square feet build alternative will allow for the greatest improvement in ambient air quality.

TABLE 7

NET AIR QUALITY INDICES FOR THE FOUR BUILD ALTERNATIVES IN 1985 RELATIVE TO THE CURRENT (1975) CONDITION

	Receptor Site	Net Air Quality Impact Indices			
		3M	4M	5M	6M
1.	Public Garden	0.33	0.33	0.33	0.33
2.	Charles Street	0.35	0.37	0.40	0.39
3.	Boston Common	0.33	0.33	0.33	0.33
4.	Theater District	0.33	0.33	0.33	0.33
5.	Stuart Street	0.37	0.40	0.45	0.45
6.	Howard Johnson's 57 Hotel	0.46	0.56	0.73	0.72
7.	Statler Hilton Hotel	0.34	0.34	0.36	0.36
	Seven-Point Average:	0.36	0.38	0.42	0.42

IV. REFERENCES

1. Johnson, W.B., Dabberett, W.F., Ludwig, E.L., and Allen, R.J., *Field Study of an Urban Diffusion Model for Carbon Monoxide*, Stanford Research Institute, Menlo Park, California, 1971.

2. Mancuso, R.L., and Ludwig, F.L., *User's Manual for the APRAC-1A Urban Diffusion Model Computer Program*, Stanford Research Institute, Menlo Park, California, 1972.

3. *Compilation Air Pollutant Emission Factors*, U.S. Environmental Protection Agency, Office of Air and Water Programs, Publication No. AP-42, Second Edition, Supplement No. 2, Research Triangle Park, North Carolina, September 1973.

4. Kircher, D.S., and Armstrong, D.P., *An Interim Report on Motor Vehicle Emission Estimation* (Draft), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, October 1972.

5. Smith, M., *Development of Representative Driving Patterns at Various Average Route Speeds*, Scott Research Laboratories, Inc., San Bernardino, California, February 1974.

6. *Instrumentation for Environmental Monitoring: Air*, Environmental Instrumentation Group, Lawrence Berkeley Laboratory, University of California, Berkeley, California, December 1973.

7. *Clean Air and Your Car*, Office of Public Affairs, U.S. Environmental Protection Agency, Washington, D.C., March 1973.

8. Williamson, S.J., *Fundamentals of Air Pollution*, Addison-Wesley Publishing Company, Inc., Reading, Massachusetts, 1973.

9. Research Report delivered to the American College of Surgeons, 60th Clinical Congress, Miami Beach, Florida, 1974.

10. Natusch, D.F., and Wallace, J.R., "Urban Aerosol Toxicity: The Influence of Particle Size," *Science*, *186*, 695-699, November 1974.

11. *Lead*, Committee on Biological Effects of Atmospheric Pollutants, National Academy of Sciences, Washington, D.C., 1972.

12. Symposium Proceedings, "Lead in Gasoline," Washington Academy of Sciences, Bethesda, Maryland, 1971.

V. APPENDIX

SOURCES AND EFFECTS OF AIR POLLUTANTS

A brief review of the known effects of air pollutants on health, materials, and other receptors is presented in the following sections. The air pollutants covered in this review are those for which Federal and State Air Quality Standards have been promulgated. Although scientific evidence is far from complete, extensive experimental and epidemiological studies [6, 7, 8] have verified that air pollution adversely affects health, the environment, and the economy, with the extent of such effects dependent on concentration levels and exposure time.

A. CARBON MONOXIDE

Carbon monoxide (CO) is a colorless, odorless, and tasteless gas. Background measurements over uninhabited areas indicate levels between 0.02 and 0.05 ppm, due mainly to the oxidation of methane emitted by decaying organic matter. In the urban environment, CO is the most prevalent air pollutant, and it is present at levels which are several orders of magnitude higher than the natural background. CO in the urban environment arises primarily from the incomplete combustion of carbonaceous fuels, the largest source resulting from the combustion of gasoline by motor vehicles. Since CO is relatively inert once emitted, the concentrations tend to maximize close to the source (a freeway, for example), and the pollution problem is usually localized.

CO is a toxic chemical compound. The principal toxic action of CO is a result of its combination with blood hemoglobin (Hb) to form carboxyhemoglobin. This compound interferes with the life-sustaining transfer of oxygen from the lungs to the body tissues and the return of carbon dioxide from the tissues to the lungs. The affinity of Hb for CO is more than 200 times greater than that for oxygen. Hence, the presence of relatively small amounts of CO results in significant interference with essential cardiovascular-respiratory functions. Relatively brief exposure to high levels (40 ppm) can impair time interval discrimination, visual acuity, and other psychomotor functions. An exposure time and level associated with normal

commuter, freeway driving is adequate to produce these effects. Longer exposure to higher levels may cause headaches, drowsiness, and eventually respiratory failure and death. Persons most affected by CO are those suffering from heart and pulmonary ailments. Cigarette smokers have high background concentrations in their bloodstream and may also be sensitized. CO is capable of reacting with other hemoproteins and may also interfere with certain enzyme systems. In addition, a recent research study [9] indicates that deaths resulting from overexposure to CO may be caused by massive poisoning of the cytochrome system of the body's tissue cells by CO, resulting in the rapid death of these cells. Plants are insensitive to the presence of CO, even at the high levels found in urban environments.

B. HYDROCARBONS

Hydrocarbons are organic compounds consisting solely of hydrogen and carbon. The largest component of world-wide hydrocarbon emissions is non-reactive methane from biological sources and is of lesser concern than the reactive compounds such as the olefins, aromatics, diolefins, and ethylene. These reactive hydrocarbons combine with nitrogen oxides in a complex series of chemical reactions to form photochemical oxidants. The chief sources of these reactive species are man-made and arise from the incomplete combustion of carbonaceous fuels by motor vehicles, industrial process evaporative losses, and other fuel use activities.

There are no known *direct* health effects from exposure to gaseous hydrocarbons at levels found in the atmosphere. The major known pollutant effects of hydrocarbons result from the formation of photochemical oxidants which are discussed in a following subsection. Phototoxic effects caused by alkenes to orchid and carnation crops in California near point sources have, however, been observed, but the total damage is relatively small.

C. OXIDES OF NITROGEN

On a world-wide basis, man-made source of nitrogen oxides produce only one-tenth the amount produced naturally, arising primarily from biological bacterial processes. However, urban concentrations are generally 10 to 100 times higher than background non-urban levels. In the urban

environment, nitrogen oxides arise mainly from high-temperature combustion processes which are followed by rapid cooling. Several oxides of nitrogen are found in the atmosphere, but nitric oxide (NO) and nitrogen dioxide (NO_2) are the most important air pollutants. Most of the man-made nitrogen oxides are in the form of NO, which is subsequently oxidized in the atmosphere to the more toxic and irritating NO_2, a reddish-brown gas with a pungent odor. Motor vehicle emissions and the burning of coal, oil, and natural gas are the principal sources of NO.

In addition to contributing to the formation of photochemical oxidants, nitrogen oxides have several direct damaging effects. NO_2 exerts its primary toxic effect on the lungs. High concentrations are lethal to most animal species, causing pulmonary edema. Epidemiological studies have correlated NO_2 concentrations with increases in respiratory diseases in people. Chronic plant injury is associated with exposure to NO_2. Associated problems include decreased visibility, textile fading and deterioration, and corrosion of electrical wiring.

D. PHOTOCHEMICAL OXIDANTS

Photochemical oxidants are not directly emitted by any man-made source in significant quantities. Rather, they are a class of atmospheric pollutants which arises from a complex series of atmospheric photochemical reactions between hydrocarbons and oxides of nitrogen in the presence of sunlight. The two most important reaction products are ozone and the peroxyacyl nitrates (PAN). In addition, large numbers of deleterious byproducts are formed during the reactions, including nitrate aerosols.

The observed effects of photochemical oxidants include eye and respiratory irritation, increased aging of red blood cells, impaired delivery of oxygen to the body tissues, shortness of breath, and impairment of the performance of athletes. A recent study which correlated the frequency of traffic accidents with oxidant levels showed that high oxidant levels lead to dulled senses, impaired vision, and increased driver irritability. Other experiments have found oxidants damaging to animals and vegetation. Associated material problems include the fading of textiles, dyes, and paint and the cracking of rubber.

E. OXIDES OF SULFUR

Sulfur oxides arise from the combustion of carbonaceous fuels containing sulfur compounds, most notably coal and petroleum. The predominant form is sulfur dioxide (SO_2), a colorless gas with a vile, pungent odor. In ambient air, it oxidizes and hydrolyzes to form acid sulfates and sulfuric acid by a number of different atmospheric reaction processes. Precipitation scavenging of sulfates and sulfur oxides, the principal mechanism for removal of these compounds from the atmosphere, causes increased acidity in the associated rainfall.

SO_2 is normally a mild irritant of the upper respiratory tract. However, when aerosols are present, SO_2 can be adsorbed (coated) onto the particulate surfaces, oxidized into one of the acid sulfates, and carried deep into the lung. There, in the presence of moisture, it can hydrolyze to sulfuric acid on the pulmonary membrane. Correlation studies have linked SO_2 and sulfates with the incidence of acute respiratory diseases and their associated mortality rates. Current controversy over catalytic mufflers being installed on many new model cars concerns the possibility that they may cause formation of sulfuric acid mist from the small amounts of sulfur present in gasoline. In addition, laboratory experiments have found sulfur oxides to be damaging to animals, plants, building materials, art works, textiles, and paints.

F. PARTICULATES

On a global basis, the bulk of particulate matter in the air is of natural origins. However, in urban areas, the proportion due to industrial processes, fuel burning, and road dust predominates. Particulates play an important role in air pollution for several reasons. For example, chronic exposure to high concentrations of particulate matter may be injurious to the lungs. This pollutant can also act in a synergistic role in potentiating the toxic effects of certain other pollutants, such as SO_2. Some metallic ashes catalyze the oxidation of SO_2 into acid sulfates. Particulate matter is responsible for atmospheric turbidity and reduced visibility; it is also thought to affect the earth's energy balance through changes in the earth's albedo and absorption of radiation.

It is now generally agreed that particle size is a major factor in determining the toxic effects of airborne particulate matter [10]. In general, pulmonary deposition increases as particle diameters decrease, with particulate matter less than 1 μm in diameter of primary importance. Recent studies have shown a number of potentially toxic trace species, including lead, predominate in small, lung-depositing particles in most urban aerosols.

There is much concern over ambient concentrations of lead particulates in urban environments; the major source of such airborne lead (98%) is the burning of gasoline containing tetraethyl lead additives [11]. The health effects of airborne lead are somewhat controversial. Lead is known to be a poison, and it is cumulative in the body. Lead poisoning can give rise to several acute and chronic diseases. It has been reported that lead in the bloodstream may interfere with maturation and development of red blood cells, cause disturbance of enzyme activity, and interfere with liver and kidney functions. However, studies [12] have shown no cases of illness or death to animals or people traceable to lead particulates from motor vehicle exhausts.

Of all lead normally taken into the body of the typical urban adult, only 25-30% comes from inhaled air [10]. With the development and increasing use of unleaded fuels, this contribution should decrease with time. There are currently no Federal or Massachusetts Ambient Air Quality Standards for lead particulates.

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